

## **SYMPOSIUM SUMMARY**

### **General**

About 100 scientists representing 20 countries, 37 universities and 15 research institutes attended the international symposium on Forest soils under global and local changes: from research to practice. The meeting lasted 2.5 days of oral and poster presentations, 1.5 days of excursions. The meeting was sponsored and organized by following organizations:

International Union of Soil Sciences (IUSS)

International Union of Forest Research Organisations (IUFRO) -Division 8

European Institute of Cultivated Forests (IEFC)

Institut National de la Recherche Agronomique (INRA)

Ecole Nationale d'Ingénieurs des Travaux Agricoles (ENITAB)

There were seven plenary sessions and one initial (welcome) session and one final (summary and recommendations) session for which the details are given below as provided by the session chair of each session.

### **Plenary Session 1 – Carbon and Greenhouse Gases**

#### **Session Chair: Prof. Manuel Maderia**

The topics of carbon sequestration by soils and the effects of Greenhouse gases were evaluated in the key note address by Dr Rainer Baritz with respect to the requirements placed by the policy managers on the assessment of changes. Various presentations in this session gave an update and some deep insights into the issues of C sinks and fluxes in forest soils.

The main items of interest were:

- It was emphasized that it is essential to devote more research efforts to study spatial and temporal changes due to high variability at the local and regional scale. It is crucial to combine information from soil surveys with that of management in the context of the system: soil-climate-management practices.
- New attempts of modelling C fluxes were presented taking into account abiotic (temperature and moisture) and biotic (vegetation species) factors.
- Research on C pools in forest ecosystems and their spatial and temporal variation were provided including dynamics of C in biomass components and in the forest soil.
- Development of methodologies for soil respiration and soil CO<sub>2</sub> concentrations were also presented.

### **Plenary Session 2: Soil Biology**

#### **Session Chair: Prof. Helga Van Miegroet**

The presentations in this session covered the nature and extent of changes in soil biota and their activity under future global change scenarios and land use changes.

The key note speaker, Martin Potthoff, introduced the topic by discussing the role of soil as a habitat for diverse soil organisms and the potential effect of management and global change on soil function through habitat modification. With case studies he illustrated the idea that soil

biological impacts following perturbations should consider life-forms and their habitat needs rather than simple taxonomy and species abundance. The subsequent paper by Jean-Francois David further elaborated on the concept of ecological amplitude of organisms and tolerance to habitat change using a north-south gradient study in Europe as a proxy to test future climate change scenarios. This study suggests that saprophagous macrofauna activity may not undergo substantial change under warmer/drier climate conditions due to the ubiquitous nature of these organisms and their adaptation to climatic extremes. The two remaining papers by Jacques Ranger and Zhihong Xu, specifically focused on the response of nitrogen transformations to changes in vegetation composition, showing that pre-existing soil conditions and vegetation are key parameters in determining the future trajectory of soil nitrogen biogeochemistry following forest conversions.

### **Plenary Session 3 - Productivity and Nutrition**

#### **Session Chair: Prof. E. Farrell**

This session, perhaps more than any other, exemplified the international nature of this conference. The benefits which may accrue from the exposure of one's own experience, preconceptions and assumptions to other perspectives from contrasting environments and ecosystems are potentially enormous.

Our keynote speaker, Jose Gonçalves, gave us a fascinating insight into constraints in high-yielding eucalypt plantations in Brazil. Soil texture is an important indicator of soil quality in these plantations, due to recurring water stress, but nutrient supply, chiefly nitrogen and phosphorus can also be growth-limiting.

Jose was followed by four excellent presentations, two from Spain and one each from Switzerland and New Zealand. Peter Clinton spoke of the need to better understand how the forest productivity is influenced by site quality in New Zealand. He described uniquely designed long-term productivity trials in *Pinus radiata* and *Cupressus lusitanica*. He was followed by Miguel Balboa Murias, from Lugo, who reported on above and below-ground biomass in *Quercus robur* stands in Galicia. Gerardo Moreno took us to the quite different landscape and climate of Extramadura, where he has been working on holm oak (*Quercus ilex*) in dehesas under different vegetation and land use conditions. The soils of the dehesa are of generally low fertility. However, when no longer in agricultural use, encroachment of vegetation occurs, resulting in an improvement in the phosphorus status of the holm oaks, but a deterioration in their nitrogen and calcium status.

Patrick Schleppei concluded the session with a presentation of studies which are, essentially an extension of the now-concluded NITREX project. In this project, coniferous forest ecosystems were subjected to experimental manipulation involving altered nitrogen deposition. In Patrick's study, effects of enhanced nitrogen additions have been studied in a paired catchment experiment for a period of ten years. The benefits of extending the work beyond the lifetime of the project were clearly evident in that many response of the ecosystem became apparent only after several years of treatment. The results emphasise the need, in forest research, for projects of longer duration than conventionally programmed by funding agencies.

Several interesting and useful posters were presented under this session heading. Elena Vanguelova presented the results of a soil acidification experiment in the United Kingdom which generated soil solution concentrations of monomeric aluminium and base cations

which strongly suggest a threat to the sustainability of the ecosystem. Another poster concerning root growth in the eucalypt plantations in the Congo demonstrated a diversity of rooting habit related to the availability of soil moisture. The poster by Carlos Ribeiro and Manuel Madeira presented data on decomposition processes of root litter of *Eucalyptus globulus* and *Pinus pinaster*. The fertility of the soils of Costa Rica was the subject of a poster by Amelia Paniagua-Vásquez. Last, but no means least, Barbara Cade-Menun's poster presentation emphasised species differences in the nutrient cycling capacity of Douglas fir (*Pseudotsuga menziesii*) and western red cedar (*Thuja plicata*) which has significant implications for plantation forestry in Europe.

## **Plenary Session 4: Sustainable Forest and Soil Management**

### **Session Chair: Dr J. Ranger**

In his key note address on the concept of sustainability Dr E. Farrell (Dublin) described the problems associated with the inclusion of the multifunctional role of forests rather than just the production forestry. His talk described in an elaborative manner, with many practical examples, the state of art in the use of the concept of sustainability, the expectations and the associated problems.

There were two presentations providing details of how the systems function. The first one described the effects of clear cutting of forests on SOM changes by Bally et al (University of Dijon, France). The Spatio-temporal approach (short term study) showed that on this site changes induced by clearcutting were related to harvesting operations. Recovery of SOM occurred quite rapidly but it is better to have long term investigations.

The second paper considered the long term changes in soil fertility as assessed with the help of Sr isotopes by Th. Drouet et al from Bruxelles University, Belgium. This study used the concept of two sources of nutrient for growth – soil and atmospheric depositions. Forest trees increase complexity through nutrient cycles but simple conceptual models work because the discrimination of Sr isotopes occur due to biological processes. Sr was considered to be analogous to Ca and thus could be used as an indicator of soil acidification during atmospheric depositions and other processes.

In addition 15 posters were presented in this session which covered many topics (soil processes (3), effect of species (3), soil carbon (3), nutrient cycles (3), harvesting (1) and simulation of forest behaviour from soil characteristics (1).

## **Plenary Session 5: Hydrological cycles**

### **Session Chair: Dr Agustin Merino**

Eight papers were presented during this session from Austria, Spain, Portugal, Finland, Germany and Belgium.

A through overview on the influence of forest on water cycle and water quality were presented by the key speaker Prof. Dr Herbert Hager. He used many case studies from literature and his own work to show the factors determining different water fluxes in a forest ecosystem on a site and also on the landscape or catchment scale levels. He showed that the depletion of water by spruce and beech stands was different due to differences in interception losses at the canopy, litterlayer and soil (different water use patterns), higher amount of water used by spruce than beech, but the WUE was higher for spruce. Use of thinning the stands as a management option to change the water cycle and the effect of heavy harvesting machinery which would change the soil volume through compaction were also discussed.

Papers which followed this key note address included the changes in soil water quality due to tree species, and the contribution of water from deeper soil layers for agroforestry systems involving chestnuts. The posters included changes in nitrogen losses due to soil scarification on a clear cut area, potential use of microcups to collect soil solutions, production and leaching of nitrate in heavily infested forest by beetles, changes in soil water dynamics under dehesas and changes in soil porosity and waterlogging under declining oak forests.

## **Plenary Session 6: Disturbances and site restoration**

### **Session Chair: Prof. Zhi-Hong Xu**

Dr Huettl presented in his key note address the essential features of ameliorative measures to rehabilitate the landscape following open-cut mining operations have ceased. The acidity and low fertility of the material provides a challenge to management practices but the unique research opportunities to follow the development of ecosystems with no background history (time scale equal to zero). This shaping up of a new landscape requires multidisciplinary approach, is highly cost intensive but offers unique opportunities to conduct ecosystem research.

The first paper by Juergen Bauhus (Univ. Freiburg) described changes in soil C following tree plantings with and without N-inputs (either through atmospheric N-fixing trees or through fertilization). The type and amount of SOM varied among treatments, without any gains of soil C (only losses) on the NPK fertilized site and probably minimum loss on N-fixing acacia sites. The mobility of recently sequestered C was also described through density fractionation of sand sized particles.

The second paper by Carneiro et al. described long term changes in the understorey in relation to slash management practices under a eucalypt plantation in Portugal. The third paper by Takahashi et al showed how tree species in Japan had different Ca requirements and cycling. The role of vegetation in changing soil parameters has important implications for land managers.

## **Plenary Session 7: Residues recycling in forests**

### **Session Chair: Dr Peter Clinton**

The importance of relationships between plants and soils is well recognised. Such relationships are especially important for forest ecosystems where the cycling of energy and nutrients is critical for the productivity of these systems, and these fluxes are manipulated to increase the economic outcomes for society. Although it is well recognised that cycling of litter and other plant derived materials is critical to the sustainability of forest production, new demands are being made by society on forest ecosystems in terms of wider goals of improved environmental performance and recycling of residual materials. In parallel with increasing waste quantities in our societies, they are new expectations to develop better integrated waste and natural resource management. In some cases, application of organic residuals to forests is viewed as the preferred option for disposal or reuse; changing pressures in other land use systems and water resources has brought about this need.

The use of residues from outside the forest has placed new challenges to forest managers, land owners and society at large. In turn, this has brought about the need for research to address fundamental issues of waste characterisation in terms of constituent nutrients and contaminants and behaviours facilitated by these characteristics in response to various environmental conditions including differing soil types, climates, and management systems and requirements. Many new challenges require resolution if the use of residues in forests is

to be widely adopted and accepted by society. This will require research of a participatory nature involving affected communities, researchers and policy makers so that waste management strategies are sustainable.

It is important that long-term studies of residue applications to forests are established in a range of environments to avoid making invalid conclusions based on the use of unsuitable methods or time spans that do not represent full term rotations or exposure periods. It is important to bring together toxicologists, forest managers, soil scientists and policy makers and the public so as to formulate sustainable management practices for the wide spread use of a range of residues in forest ecosystems. It is expected that this area of research will continue to expand in breadth in the near future to include such issues as the fate of pharmaceuticals and the impact of residues on biodiversity, soil quality, environmental performance and sustainability. This expansion will occur as improved waste processing increases the production of residues that may be less favourable for the environment.

## **Final Plenary Session: Summary and recommendations (P.K. Khanna and W. Burghardt)**

### **Rationale and aims of the meeting**

- Multiple functions - single forest ecosystems but in context of landscape management.
- Changing climate conditions, forest use at the local and landscape levels - productivity, environmental and other functions
- Changing social and political demands at local, national and international levels
- adaptations of present management practices and develop future management strategies

### **Three factors are distinct for managing forest soils**

- Forest soils – low quality landscape units
- Sustainability demands
- Multi - functions

### **Multifunction – Global demands – C sequestration, GHG Session 1**

- Soils are sinks or sources?
- A relatively recent issue
- Where? How much? How? Why? What can be done in terms of changing the management?
- Presentations included CO<sub>2</sub> release, or the effects of increase in atmospheric CO<sub>2</sub> on soil processes
- Problems – soil heterogeneity, especially those associated with flux measurements
- Lack of other GHG – probably few groups are working on it, still important e.g., nitrogen losses or methane absorption – soil compaction.
- Understanding at a single site level – increasing refer the key note address by Dr Rainer Baritz
- Very little progress to predict changes at the landscape level – one paper by e.g., change in soil C levels associated with productivity changes (Scand. Forests), Eddy flux measurements – not yet validated, models – landscape levels not yet available for forest areas, especially for GHG

### **Multifunction – Biodiversity (Soil Biology) - Session 2**

- Flora and fauna – key note address by Dr Martin Ponthoff was primarily about effects of fauna, other papers on microbial biomass or through effects on soil processes.
- Soil biodiversity – still in preliminary phases of development
- Functionality – poorly understood or not easily accepted e.g., nitrate production in highly acid systems, needs to develop nitrifying or other microbial populations due to resource competition
- Resource availability and competition for scarce resources is not adequately considered.
- Denitrification process is mostly disregarded
- Some attempts to develop models to assess N mineralization, but our knowledge of other important elements eg., organic P or even the release of heavy metals complexes with organic matter is poor.
- Site specific factors are poorly understood, their management related changes.
- Landscape level factors have not been worked out.

### **Multifunction– Productivity and Nutrition- Session 3**

- Key note address by Dr Leonardo Goncalves showed clearly the limitations set by the nutrient and water interactions – especially the amount of stored water in the soil profile (related to texture) provided a very simple but useful manner of predicting productivity function on a landscape level
- There are many other major players in the area of productivity especially of plantations and some of them presented their results here. In some areas e.g., New Zealand the limiting factor is not water as much as we have in Brasil, Spain, Portugal and many others.
- Site specific – precision forestry will be an issue in future
- Decision support systems – other models
- Landscape level models -3PG and other models are available
  - Future needs especially for landscape level
  - Simple
  - Useable – validation ability

### **Multifunction - Sustainability of Forest and Soil Resources - Session 4 :**

- Key note by Ted Farrell: Site specific and landscape based management issues
- Topics of oral and poster presentations:
  - \*Fertility, productivity
  - \*Nutrition
  - \*Site and stand properties
  - \*Management
- Conclusions:
  - Sustainability appears to have become a fashion term rather than as a precisely defined management target
  - The sustained targets must be more clear, also in forestry
  - Can soil quality be used as an appropriate concept for forest soils?
  - Is there a concept available which describes the different demands to forests and properties of soils and sites related to them ?
  - European Union is considering the need of an European Soil Conservation Service. (CIRCA, Library, Soil Policy, WG Research, TG7)
    - \*Should it include forest soils ?

\*Traditional soil conservation deals with soil use, protection and amelioration. Meets this concept the requirements of forest soils?

- Should we distinguish soil conservation and soil management ?

\*Soil conservation: deals with long term effects, e.g. soil fertility

\*Soil management: deals with yearly input and its short time return, productivity.

### **Multifunction - Hydrological cycle - Session 5:**

#### Topics:

Soil depth

Groundwater availability

Leaching

Key note by Prof. Herbert Hager

#### Conclusions:

- Enormous complexity of parameters of water balance

- To consider the amount of water and water quality together

- Is amount of water and water quality an issue of modern soil conservation

- Importance of local and regional land use

### **Multifunction: Rehabilitation role for disturbed landscapes, residues recycling and site restoration (Sessions 6 and 7)**

Key note 1: Reinhard Huettl – Characteristics and effects of ecosystem disturbances and consequences for site restoration

Key note 2: Jean-Michel Carnus: Recycling of residues on forest land – slash management, ash, sludge, others.

#### Topics:

Addition of materials

Harvest materials

Mine soils

Heavy metal transfer, leaching

Biodiversity

N - fixation

#### **Conclusions**

-For large areas soils are destroyed and replaced by humans. The result are degraded and raw soils

-They have no natural relationship to their landscape beside to be the result of soil use

-They can have extreme features

-Are forest soils suitable to assist soil development

-Are forest soils suitable to mitigate soil degradation

-Which role can forest soils play to protect and integrate extreme soils and their habitats in existing landscapes.

-Are these task of a Soil Conservation Service?

### **Additional issues raised and comments made by participants:**

1. To involve private organisations in the communication processes, such as this meeting.
2. To obtain a better understanding of the relationships between ecosystem processes at the site and the landscape levels it is important to understand lateral or spatial type variations in the soil and vegetation components.

3. If landscape level forms the third dimension, changes in processes in time would form the 4<sup>th</sup> dimension which would warrant consideration, especially when recommendations at the policy level are to be made.
4. To influence the political decision making processes, one needs to develop communications strategies which aim specifically at the decision making bodies.
5. High quality water from the forested landscape will become an important function of forest management in future.
6. Soil quality standards need further discussion in forestry context, especially considering the multifunction aspect of forestry. Important is to avoid the contamination of forest soils.
7. Has balanced system a high level of soil quality ? Maintenance of biodiversity is an importance criterion.
8. Resilience of the system to change or resistant to change needs to be considered when discussing sustainability of forest ecosystems. Microbial – plant interactions may provide some useful indicators in that sense.
9. Land use change – aims of change (usually multi-facet) will determine the effects on forest soils.
10. It is important to understand the soil processes first before we define the soil quality. It is probably easier in Agriculture ecosystems where productivity is the main function. In forestry there are multiple functions to cater for and not all interactions among soil processes are appropriately understood.

After giving a vote of thanks to the organisers the symposium was concluded.

P.K. Khanna  
Chairman – Scientific organising committee